

NREL FACILITIES

NREL's Outdoor Test Facility

...advancing photovoltaic technology



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What is Photovoltaic Technology?

Photovoltaic devices, commonly called solar cells, use semiconductor material to convert sunlight directly into electricity. Photovoltaics provide electricity for calculators, satellites, highway traffic signs, roadside telephones, streetlights, water pumps, homes, commercial buildings and utility electrical power grids. The total world market for photo-

Since the 1980s, when U.S. photovoltaic (PV) companies wanted independent testing of prototype products, they turned to the National Renewable Energy Laboratory's (NREL) Outdoor Test Facility. At the OTF, an integral part of the National Center for Photovoltaics (NCPV), researchers use advanced state-of-the-art laboratories and outdoor test beds to characterize the performance and reliability of PV cells, modules and small (1- to 5-kilowatt) systems.

The 10,000-square-foot OTF is to photovoltaics what an experimental test track is to the automotive industry. Working closely with their photovoltaic community colleagues—especially those in industry—researchers at the OTF study and evaluate advanced or emerging PV technologies under simulated accelerated indoor and outdoor conditions, and prevailing outdoor conditions.

The research provides verification, characterization or modeling of technology performance; quantitative assessments of reliability; identification of failure and/or degradation mechanisms; and strategies to improve reliability and/or performance. This improved understanding of the photovoltaic technologies is also used to aid industry in developing new and/or improved standards and codes.

voltaic products exceeded \$1 billion in 1999.

Continued growth of the photovoltaic market depends on several key factors, including performance (efficiency, reliability) and price (cents per kilowatt-hour) of the delivered electricity.

Indoor Laboratory Testing

Environmental Testing—Specialized chambers in the high-bay area test the performance of modules when exposed to varying weather conditions such as heat, cold, humidity, moisture and ultraviolet light. Modules are tested in high-voltage and wet conditions to evaluate electrical insulation and moisture intrusion that can cause corrosion, ground faults, or pose an electrical safety hazard. Mechanical tests include module flexing, static loading and simulated 1-inch-diameter hail strikes.

Indoor Accelerated Testing—Accelerated testing is conducted on photovoltaic modules, electrochromic windows and solar mirrors. In these tests, relative and absolute performance is determined for samples exposed to continuous light and/or elevated levels of temperature and humidity.

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Indoor Environmental Chamber Testing

Failure Analysis—Researchers in the laboratory perform destructive and non-destructive analysis to determine failure mechanisms in cells and modules. New measurement techniques and tests are developed to help identify future problems.

Cell and Module Characterization—Indoor cell and module characterization is performed with four different simulators. Current versus voltage (I-V) measurements are made using continuous, pulsed and concentrated light. Measurements can be made at Standard Test Conditions (STC) or at various temperature and irradiance levels.

Outdoor Testing

Primary Reference Cell Calibrations—Calibrations of primary reference cells are conducted at the OTF. These calibrated cells provide the photovoltaic community with a path of traceability to standards.

Standard Outdoor Module Characterization—Outdoor module characterization is conducted with the Standard Outdoor Measurement System (SOMS). This system takes I-V curve measurements at conditions as close as possible to Standard Test Conditions.

Long-Term Module Outdoor Performance and Stability—Long-term module performance testing is conducted on the Performance and Energy Rating Testbed (PERT) and in the array field. More than 30 modules of various technologies are monitored continuously for performance under various weather conditions. Outdoor exposure and stability tests are conducted on more than 50 photovoltaic modules in the array field.

Outdoor Accelerated Testing—Two testbeds are dedicated to stressing photovoltaic modules under accelerated conditions outdoors. The high-voltage stress testbed (HVST) places 600-2000 volts across the module leads and frame and then measures leakage currents. The Outdoor Accelerated-weathering Tracking System (OATS) reflects sunlight at 2.5 concentration to increase the light exposure on the modules.

Grid-Tied PV Systems Testing—Seven grid-tied, 1- to 2-kilowatt photovoltaic systems are installed at the OTF. These systems employ various photovoltaic module technologies, including copper indium diselenide, cadmium telluride, amorphous silicon and crystalline silicon. These systems are monitored for long-term performance and reliability.

Stand-Alone PV Systems Testing—Several types of stand-alone photovoltaic systems are monitored at the OTF, including remote solar home systems and area streetlights. Test procedures are developed to determine how well the system components perform as a complete system.

Developing Standards and Codes

Researchers at the OTF also work with industry to set uniform and consensus standards and codes for testing photovoltaic devices. These standards and codes include IEEE, ASTM, IEC and NEC.



Pulsed Solar Simulator for Module Characterization

NREL Contacts

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NCPV Information: www.nrel.gov/ncpv